Commercial Building Energy Information Handbook

Technical Advisory Committee Meeting

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http://eis.lbl.gov

Sponsored by the US Department of Energy
Alan Schroeder and George Hernandez

Meeting Agenda

- Participant role call – name and organization (10 min)
- Review of tasks and timeline (5 min)
- Selections from working draft – review modifications, additions based on feedback (20min)
- Discussion (15 min)
- Next steps (5 min)

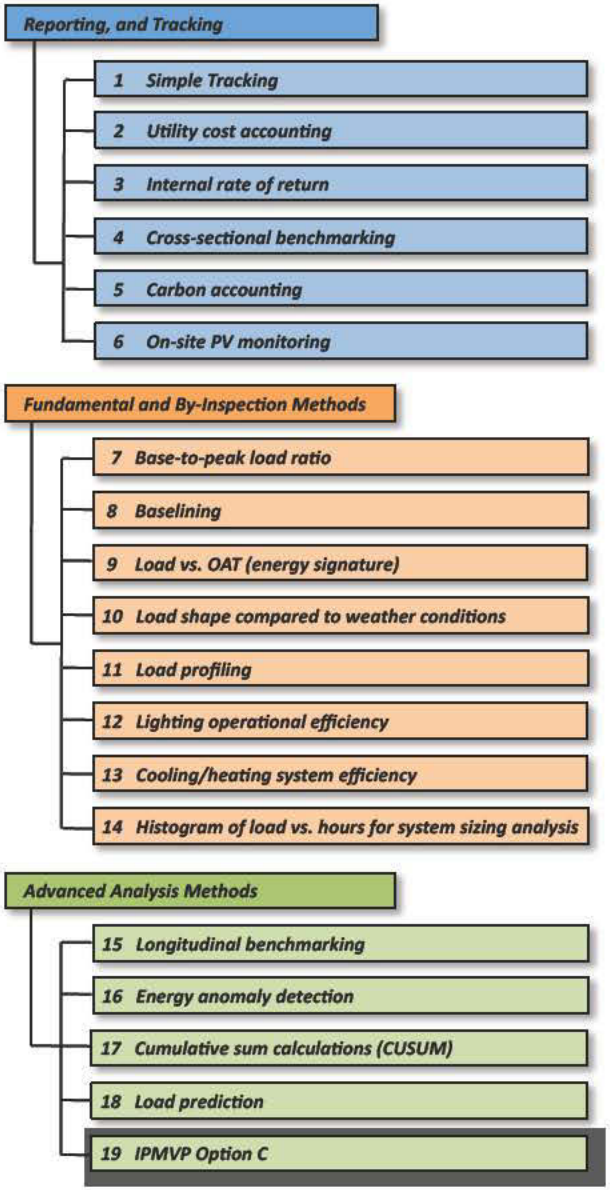
Tasks and Timeline

1. Develop template for summaries of analysis methods, Dec 2010
2. **Select analysis methods for inclusion, Feb 2011**
3. **Develop 3-5 sample summaries of methods, Mar 2011**
4. **Identify examples of application benefits, continuous**
5. Develop initial draft analysis guide, Jul 2011
6. Finalize analysis guide, Sept 2011
7. Define and scope Phase 2 research plans, Sept 2011

Meeting Agenda

- Participant role call – name and organization (10 min)
- Review of tasks and timeline (5 min)
- Selections from working draft – review modifications, additions based on feedback (25min)
  - Final selection of methods
  - Quick-glance summary charts
  - Advanced methods
  - Related methods
  - Audience and level of detail
  - Application examples
- Discussion (10 min)
- Next steps (5 min)

Final Selection of Methods



- Final list combines DOE desire for simplicity, LBL input, and TAC votes
- Removed whole-building/system-component categories within each primary section
- Included GHG emissions
- Preferred metrics for heating/cooling system efficiency reflected in method selection
- Baselining will have two sections, simple normalization and model-based
- Comment that the 2 benchmarking methods go together deferred to co-author

Final Selection of Methods

- FDD comprises the final chapter, will include discussion of market trends and directions

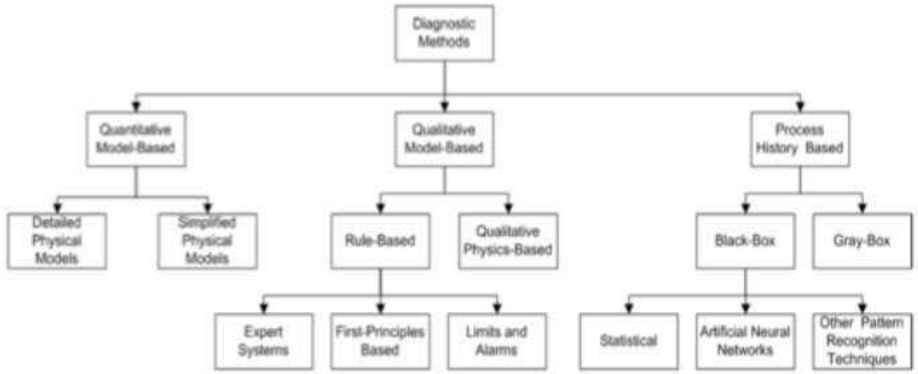
Fault Detection and Diagnostics

Introduction

- What is FDD – automated identification of faults (not just anomalies), and isolation of the cause
- History and timeline of application to building controls/operations

Approaches/Techniques

- Presentation of classification hierarchy in the figure below
- Description of the three methods types at the top tier – quantitative model-based, qualitative model-based, process history based



Classification of FDD methods[2]

Quick-glance Summary Charts

- Compare and contrast across the entire set of methods

Required Data Sources

Analysis Method	Utility		Interval Meter		Submeter			Other
	Gas	Electric	WB Gas	WB Electric	Heating Load	Cooling Load	Lighting Load	
1 Simple tracking	●	●						
2 Utility cost accounting	●	●						
3 Internal rate of return	●	●						
4 Cross-sectional benchmarking	●	●						
5 Carbon accounting	●	●						
6 On-site PV monitoring								●
7 Base to peak load ratio			●	●				
8 Baselining	●	●	●	●	●	●	●	●
9 Load vs. OAT (energy signature)	●	●						●

Quick-glance Summary Charts

- Assume some readers will not know what they're looking for

Applicable Systems

Analysis Method	 Whole Building	 Heating	 Cooling	 Lighting	 Plug Loads
1 Simple tracking	●	●	●	●	●
2 Utility cost accounting	●				
3 Internal rate of return	●	●	●	●	●
4 Cross-sectional benchmarking	●	●	●	●	●
5 Carbon accounting	●				
6 On-site PV monitoring *					
7 Base to peak load ratio	●				
8 Baselining	●	●	●	●	●
9 Load vs. OAT (energy signature)	●	●	●		

Quick-glance Summary Charts

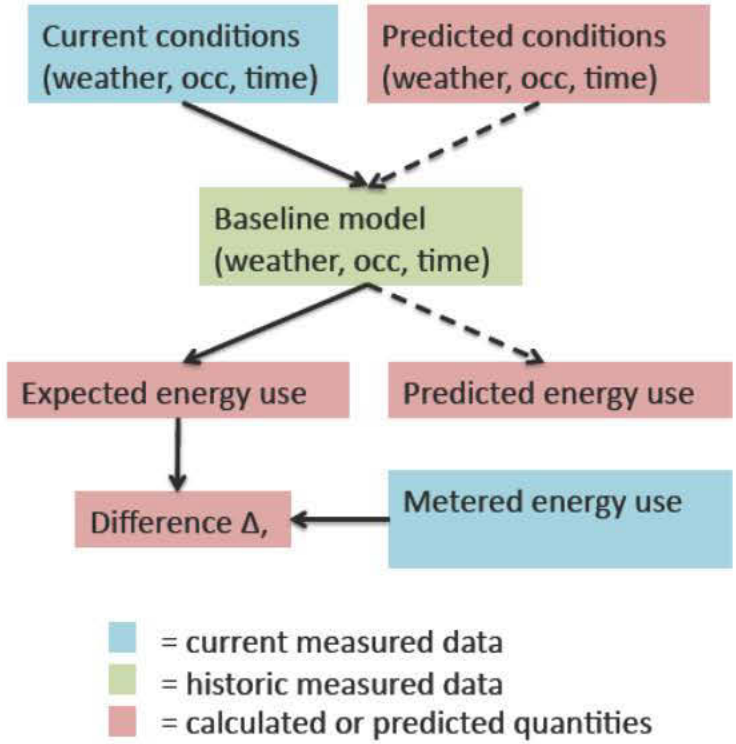
- Make it easy for readers to flip between similar methods

Methods of Interpretation

Analysis Method	Requires Minimal Expertise	Rule of Thumb	Requires Domain Expertise
1 Simple tracking	●		
2 Utility cost accounting	●		
3 Internal rate of return	●	●	
4 Cross-sectional benchmarking	●	●	
5 Carbon accounting	●	●	
6 On-site PV monitoring			●
7 Base to peak load ratio	●	●	
8 Baselining	●		●
9 Load vs. OAT (energy signature)			●

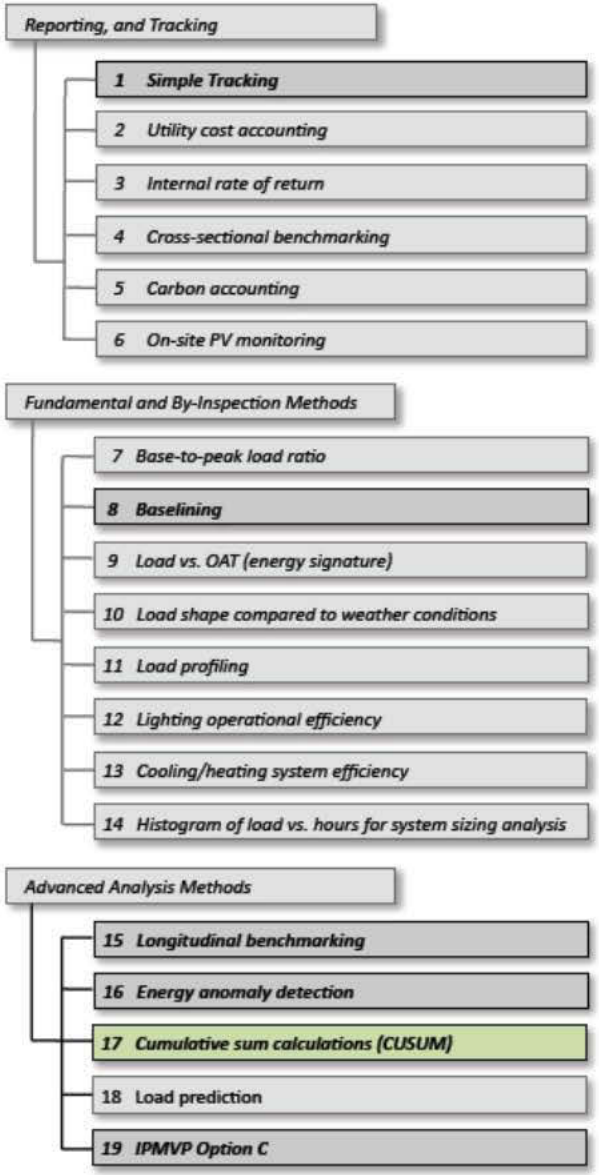
Advanced Methods

- Consider how to treat the relationships between the methods, given that the methods in some ways are not discrete, but rather overlapping variations on the same technique



Technical Approach	Associated Method
Future predicted conditions input into baseline model	Load prediction
Difference between expected metered energy use	IPMVP Option C to determine energy savings
Difference between expected metered use, accumulated over time	Cumulative sum
Difference between expected and metered use, combined with a threshold value	Energy anomaly detection

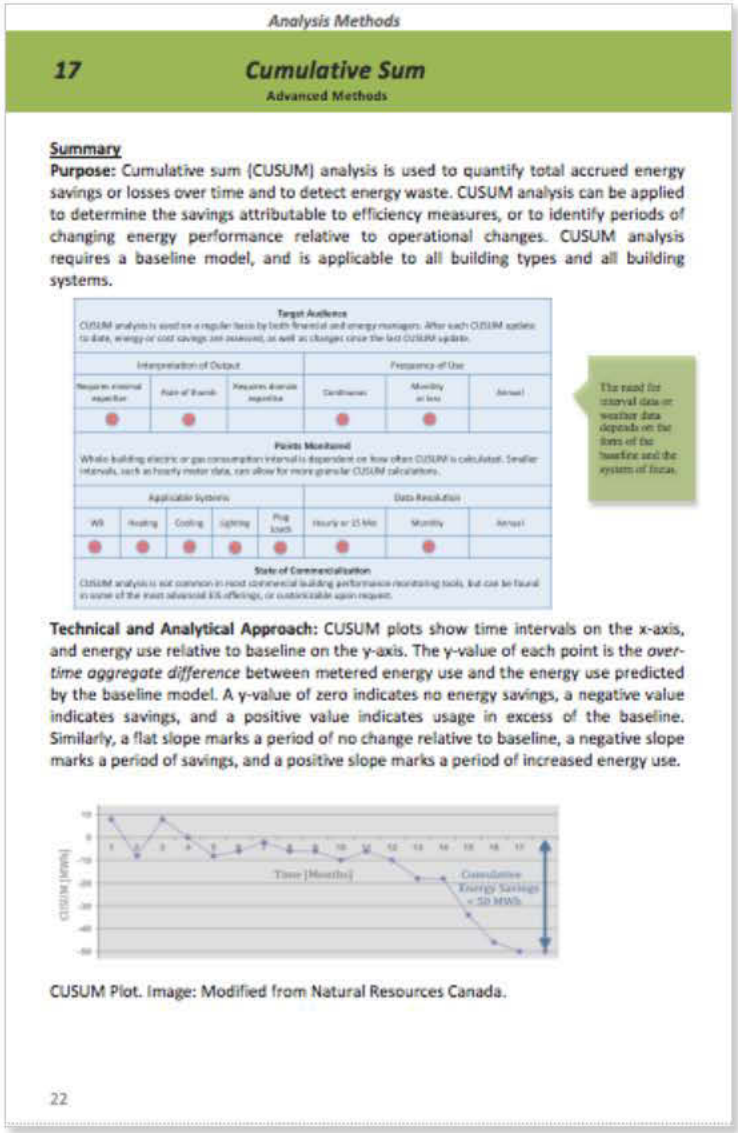
Related Analysis Methods



Simple tracking is related because it also used to track up/ down energy consumption over time. It is a simpler version that does not include a comparison of current energy consumption to a baseline.

- Methods that are related to the summary method are called out
- Summary of how they are related

Audience and Level of Detail



Analysis Methods

17 **Cumulative Sum**

Advanced Methods

Summary

Purpose: Cumulative sum (CUSUM) analysis is used to quantify total accrued energy savings or losses over time and to detect energy waste. CUSUM analysis can be applied to determine the savings attributable to efficiency measures, or to identify periods of changing energy performance relative to operational changes. CUSUM analysis requires a baseline model, and is applicable to all building types and all building systems.

Target Audience

CUSUM analysis is used on a regular basis by both financial and energy managers. After each CUSUM update to date, energy or cost savings are assessed, as well as changes since the last CUSUM update.

Interpretation of Output			Frequency of Use		
Requires interval expertise	Point of Diminishing Returns	Requires diminishing expertise	Continuous	Monthly or less	Annual
●	●		●	●	

The need for interval data or weather data depends on the aims of the baseline and the system of focus.

Points Monitored

Whole building electric or gas consumption interval is dependent on how often CUSUM is calculated. Smaller intervals, such as hourly meter data, can allow for more granular CUSUM calculations.

Applicable Systems					Data Resolution		
WB	Heating	Cooling	Lighting	Plug Loads	Hourly or 15 Min	Monthly	Annual
●	●	●	●	●	●	●	

State of Commercialization

CUSUM analysis is not common in most commercial building performance monitoring tools, but can be found in some of the more advanced EIS offerings, or customizable upon request.

Technical and Analytical Approach: CUSUM plots show time intervals on the x-axis, and energy use relative to baseline on the y-axis. The y-value of each point is the *over-time aggregate difference* between metered energy use and the energy use predicted by the baseline model. A y-value of zero indicates no energy savings, a negative value indicates savings, and a positive value indicates usage in excess of the baseline. Similarly, a flat slope marks a period of no change relative to baseline, a negative slope marks a period of savings, and a positive slope marks a period of increased energy use.

CUSUM Plot. Image: Modified from Natural Resources Canada.

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- The guide should be basic level, and easily used by the least technical audience of owners, managers

- Technical details should go in later chapters or an appendix

Technical and Analytical Details

CUSUM represents the cumulative difference between baseline, or expected, energy consumption and actual energy consumption over a period of time.

$$C_t = \sum_{i=1}^{t} D_i \qquad D_i = A_i - B_i$$

where

C_t = CUSUM on the tth interval

A_i = Actual energy use on the ith interval

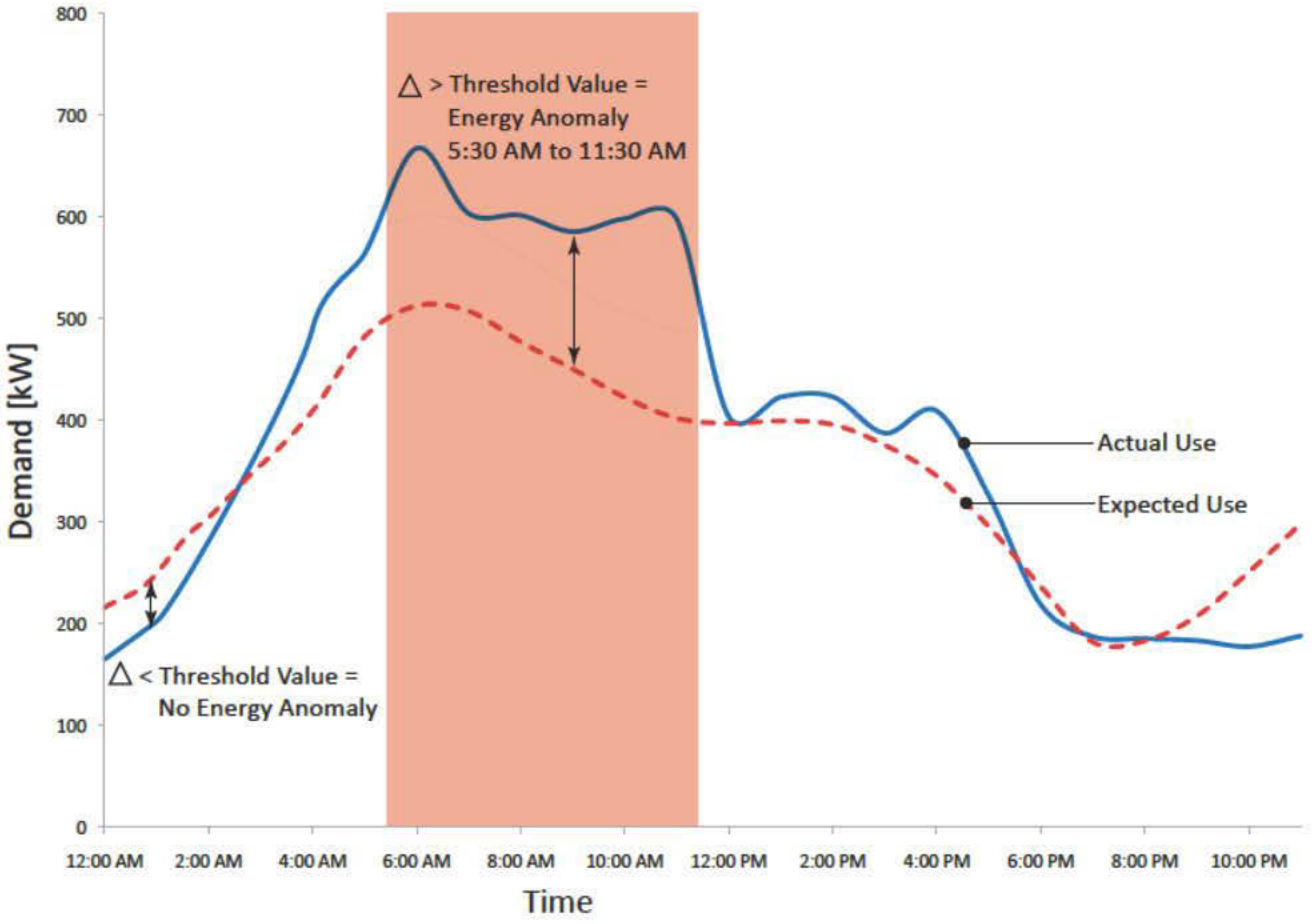
B_i = Baseline energy use on the ith interval

D_i = Difference between Actual and Baseline energy use on the ith interval

Interval [month]	Actual Use [kWh]	Baseline Use [kWh]	Difference	CUSUM (Cumulative Sum)
1	340	332	+8	+8
2	340	356	-16	-8
3	380	364	+16	+8
4	380	388	-8	0
5	300	308	-8	-8
6	400	388	+2	-6

Audience and Level of Detail

- Annotate examples for good/bad patterns, interpretation basics, and benefits of application



Application Example: CUSUM

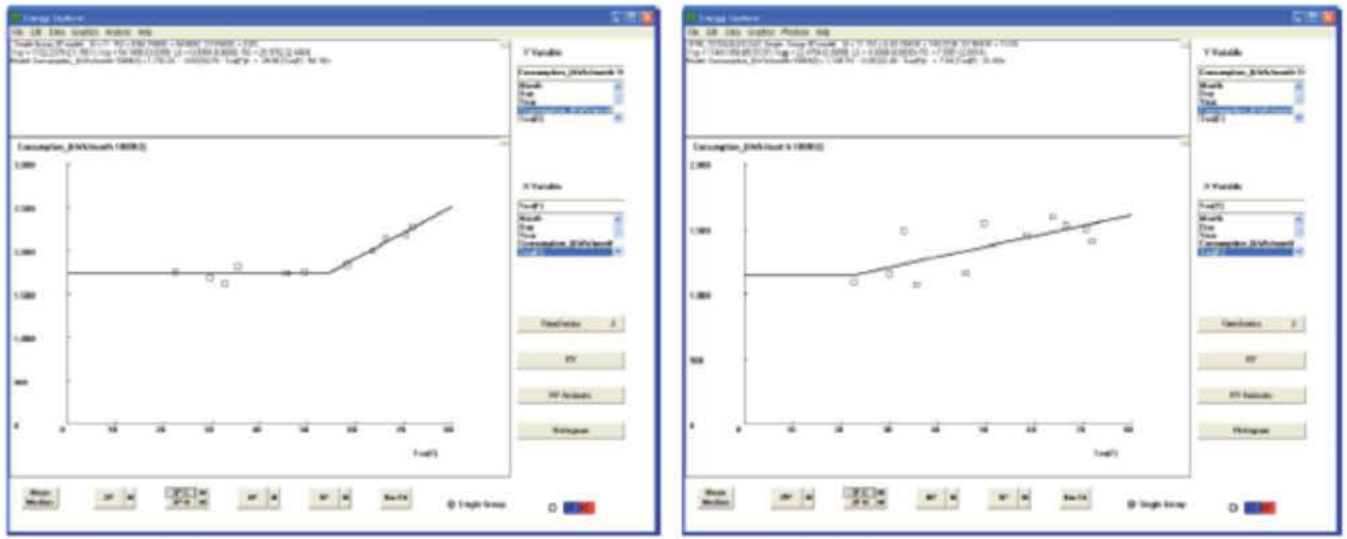
1. Initially the CUSUM hovers about zero, and then dips in August through October 2008, marking a period of energy waste.
2. 30 potential energy efficiency measures were identified onsite. Half of these measures were carried out immediately. The CUSUM rises from zero to 7,00 kWh from November through January.
3. In February 2009, the remaining measures were implemented. The slope of the CUSUM trend steepens, reflecting the additional savings.
4. By April 2009, an additional 25,000 kWh were saved, for a 5-month total cumulative savings of 32,000 kWh. [5]

In this example the common sign convention is reversed: a positive slope and y-value indicates savings.

CUSUM graph of refrigerated warehouse. Image: Modified from NorthWrite

Application Example: Load vs. OAT

These are monthly electric energy signatures[3] for two commercial buildings that are similar in construction and occupancy but have different control systems and some HVAC elements. The signature on the left shows an orderly three-point relationship with an electric baseload and a cooling slope that represents more cooling energy used as the average temperature increases, as one would expect. The chart on the right shows the effect of the control system on the second building. Due to its poor operation the system operates erratically and the points are not orderly.



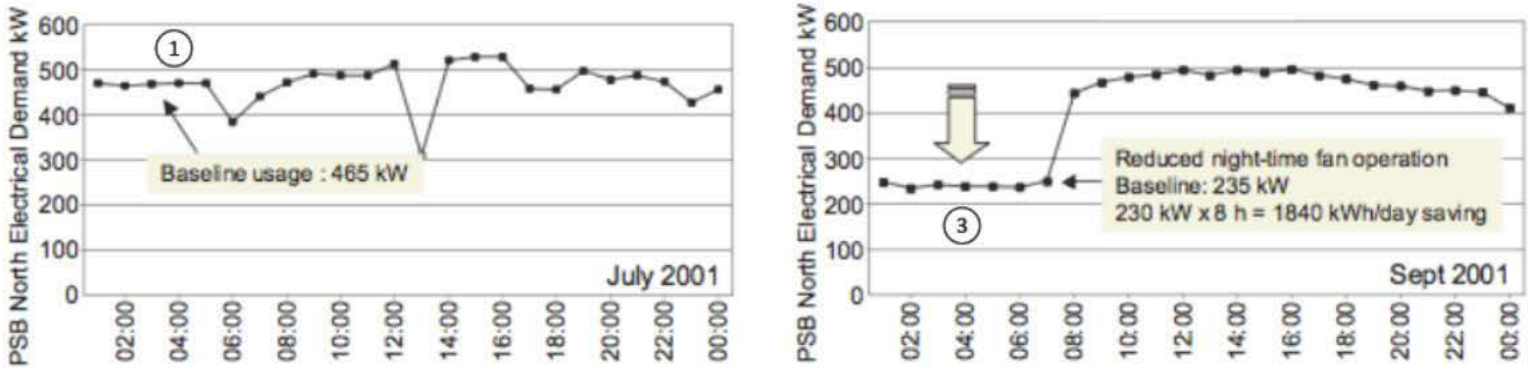
$R^2 = 0.94$ $R^2 = 0.49$

Figure 3. Side by side comparison of two monthly electric whole building energy signatures from similar buildings. Image: Kissock, University of Dayton (2010)

Application Example : Load Profiling

Electricity demand (kW) was quantified over a one-day period at a university classroom building.

1. In July of 2001, nighttime energy consumption was 465 kW.
2. The energy manager identified excessive fan speed as the likely cause of high energy use during unoccupied hours. In August 2001 building staff turned down the fan speed by 50% between 12 am and 7 am.
3. By Sept 2001, the change in load shape saved 1840 kWh per day, or about $92 per day.



Comparison of load shape during July 2001 to the load shape in September 2001 after nighttime fan operation was reduced. Image: UC Santa Barbara

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Next Steps

By **May 16** please send Jessica feedback on:

- The handbook design sketch
  - Intended layout, sections, content outlined to-date
- The methods that were drafted and distributed for your review
  - Clarity, level of detail, glaringly missing content

By **May 16** please send Jessica application examples for any methods that you have put to good use

July 2011

- A draft of the handbook will be distributed for your review and comment

Thank You!